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Do educational interventions improve prescribing by medical students and junior doctors? A systematic review

Sarah Ross & Yoon K Loke[1]

University of Aberdeen, Aberdeen and [1]*University of East Anglia, Norwich, UK*

Correspondence

Dr Sarah Ross, Clinical Lecturer, Division of Medical and Dental Education, University of Aberdeen, Medical School, Polwarth Building, Foresterhill, Aberdeen AB25 2ZN, UK.
Tel: + 44 0 12 2455 3015
Fax: + 44 0 12 2455 4761
E-mail: s.ross@abdn.ac.uk

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WHAT IS ALREADY KNOWN ABOUT THIS SUBJECT

- Recent studies have identified a problem with prescribing errors in hospitals.
- It is unclear to what extent educational interventions improve prescribing performance.

WHAT THIS STUDY ADDS

- A wide range of interventions have been tested, but most of them have been on small numbers of participants in single centres.
- The most widely tested intervention, with the greatest number of randomized controlled trials, is the WHO Good Prescribing Guide, which has demonstrated efficacy in international settings across a wide range of students.
- Further work is needed to produce high-quality educational interventions and robust evaluations.

Our aim was to review systematically the literature on educational interventions to improve prescribing by medical students and junior doctors. MEDLINE, EMBASE, Educational Resource Information Center, British Education Index, PsycINFO, CINAHL, TIMELIT, Cochrane Trials Database and grey literature were searched. Inclusion criteria were: educational interventions to improve medical student and/or junior doctors' prescribing, in primary or secondary care settings, and published after 1990. After screening 3189 records, we retrieved 11 controlled and four 'before-and-after' trials. Ten controlled trials showed improvements in the scores of the intervention group on written scenarios or clinical examination stations, but one study in junior doctors showed no effect on real-life prescription errors. Only one intervention [the World Health Organization (WHO) Good Prescribing Guide, in six randomized trials] had been tested in a variety of international settings and across a range of students at different levels. All four 'before-and-after' trials reported significant improvements in written tests or clinical stations. However, most studies tested only small numbers of participants and were affected by a range of methodological flaws. There is only moderate evidence in the literature to inform medical schools about how to prepare medical students for the challenges of prescribing. The WHO Good Prescribing Guide is the only model that has been widely used and shown to improve prescribing. Although it is based on sound principles, there is a need for further development. Robust methods of assessment are required to show clearly whether particular teaching interventions are successful.

Background

Prescribing is a complex and challenging task that is becoming increasingly difficult. There is evidence of poor prescribing by a range of doctors across different settings, whether from errors, under-prescribing, over-prescribing, inappropriate or irrational prescribing [1]. Studies have identified a range of factors behind poor prescribing at individual, environmental and organizational levels. These include lack of training, low perceived task importance and

lack of awareness of errors, as well as increasingly complex polypharmacy and patient factors, lack of standardization, and particular care environments [2–4]. First-year doctors are neither confident nor competent when prescribing, by their own assessment and that of their supervisors [5, 6]. New prescribers have also highlighted a lack of undergraduate and postgraduate education in prescribing [7, 8].

There has been recognition of the need to examine undergraduate and postgraduate education in prescribing to consider whether it is achieving the aims of creating safe, rational prescribers (including a study commissioned by the General Medical Council). In particular, concerns have focused on the decline in specific clinical pharmacology and therapeutics courses within UK medical schools over the last two decades accompanying the rise in integrated teaching and whether this has left new graduates less well prepared to prescribe [1, 9]. However, some experts have argued that there is a need to evaluate evidence for educational interventions critically and the extent to which they improve prescribing [10]. We aimed to review systematically the literature on educational interventions designed to improve prescribing skills in medical students and junior doctors.

Methods

Searching

We wished to identify studies of educational interventions to improve prescribing by medical students or junior doctors. Search terms included: education, medical education, training, teaching, continuing medical education, undergraduate curriculum, drug prescription, drug prescribing, drug utilization, physician's practice patterns, quality indicators, prescription error, prescribing error, physician, medical staff and medical student. The following online databases were searched: MEDLINE, EMBASE, Educational Resource Information Center (ERIC), British Education Index (BEI), PsycINFO, CINAHL, TIMELIT, Cochrane Trials Database. Additionally, searching of manuscript reference lists of included studies and pertinent systematic reviews was undertaken. The grey literature was included through hand searching of abstracts from relevant societies: British Pharmacological Society, International Society for Pharmacoepidemiology, Association for the Study of Medical Education, Association for Medical Education in Europe.

Study selection

The target population was medical students or junior doctors in primary and secondary care settings. Studies of interventions in senior doctors or nonmedical prescribers were excluded. An educational intervention was defined as any structured educational activity. Studies of interventions directed solely at increasing theoretical knowledge of clinical pharmacology and therapeutics, without considering the prescribing task, were not included. Complex interventions with education as only one part were also excluded. Interventions termed educational that involved only distribution of written material were excluded as we did not consider these to be representative of clinical skills training in medical schools. All study designs were considered for this review, as it was anticipated that there would be a limited literature and few, if any, randomized controlled trials. Outcomes were assessment of drug choice or prescription.

Studies from all countries were included, as many issues are generic. Studies published in English since 1990 were used as current medical education was the focus of the review.

Citations retrieved in the search were reviewed independently by both authors, and those which did not meet the inclusion criteria were excluded. Abstracts which were identified by this initial screen were reviewed and included or excluded as appropriate. Reviewers reached full consensus on eligible studies after discussion. Full papers for identified potentially eligible studies were retrieved and independently reviewed by both authors.

Validity assessment

The methodological quality of each study was assessed according to criteria based on Reed *et al.* [11], Best Evidence Medical Education (BEME) [12] and Cochrane Effective Practice and Organisation of Care Group (EPOC) criteria [13].

Data abstraction

Data abstraction was undertaken by both authors independently using a form based on previous systematic reviews and guidance on educational reviews [11]. This was tailored to answer the research questions and support consistent data abstraction.

Data synthesis

We planned to conduct a meta-analysis based on Standardized Mean Difference between intervention and control groups only if outcome measures were reported in a consistent manner and heterogeneity was <50%. If not, we aimed to provide a descriptive report categorized according to study design.

Results

Search results and study characteristics

Initial searching identified 3175 studies. A further 14 were added from hand-searching of references, giving a total of 3189.

Abstracts ($n = 411$) were selected for further screening. Of these, 151 full text papers were screened and 22 were selected for data extraction (Figure 1). From the 22, we found seven interventions that did not report any assessment results – three studies reported only student evalu-

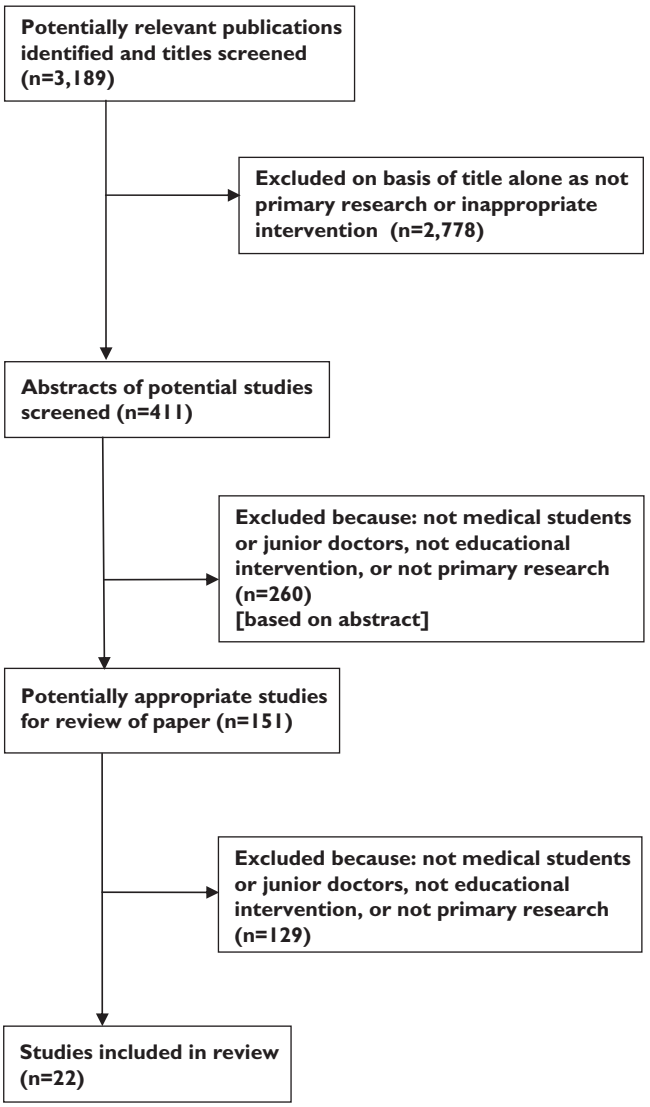

Figure 1
Flowchart of systematic review

ations of interventions, while four described interventions with no outcome evaluation (Appendix S1). Here we will report on the 11 controlled trials and four before-and-after trials included in our review.

Trial quality

Appendix S2 contains tables describing the quality of these studies.

Controlled trials

The features and results of the controlled trials are described in Table 1.

The interventions can be summarized into three broad categories.

Prescribing as a whole Eight of the trials used educational interventions that were directed at a broad range of prescribing tasks from drug history to choosing a treatment and writing the prescription [14–21]. Six trials were based on the World Health Organization (WHO) Good Prescribing Guide intervention [14–19], whereas two trials used their own in-house intervention [20, 21].

The WHO Good Prescribing Guide yielded positive results across a wide range of medical schools internationally, as well as students of different seniorities, and there was evidence of a retention effect several months post intervention [14, 15]. There was also evidence of a transfer effect, in that the students were able to perform better in applying correct prescribing principles when faced with case scenarios assessing a different disease topic [14, 15]. The main limitations of the trials were that assessments were based primarily on written case scenarios rather than practical prescribing stations, and only a limited number of disease topics were assessed (except for Vollebregt's study, which tested 21 disease areas).

Two trials looked at the effects of tutorials on general prescribing skills, but both trials were similar in that they specifically covered 'difficult' topics such as antibiotics and anticoagulation. Coombes' Australian study showed significantly improved scores in the written paper across a limited range of topics [20]. Scobie's study had only a small number of students, and reported significant improvements in five of the seven stations covering skills that had been taught. The mean overall scores in the Objective Structured Clinical Examination (OSCE) were reportedly higher in the intervention arm (statistical significance for the overall scores was not given) [21].

Dose calculation and administration Two studies had the narrow focused aim of educating participants on correct dosing and administration. The higher quality randomized study was carried out by Degnan *et al.* using an electronic interactive tutorial, and this led to improved administration of lidocaine and adrenaline in an OSCE setting [22].

Nelson's small controlled trial in 20 postgraduate paediatrics residents in the USA [23] showed improvements in written scores with the intervention, but the lack of randomization and comparability between control and intervention arms are major limitations.

Prescribing errors Kozer reported a small controlled trial with 24 postgraduate paediatric residents in Canada [24]. A teaching session on prescribing errors was attended by study participants, and actual prescribing errors were measured. No difference was seen between study and control groups.

Before-and-after studies

The main features and results are summarized in Table 2.

One before-and-after study used the WHO prescribing guide [25], again showing improvement in OSCE stations, one of which considered transfer effect.

Table 1

Characteristics and results of controlled trials

Author	Date	Setting	Study design	Number of participants	Intervention	Outcome measures	Results	Best evidence medical education score*
Akici *et al.* [14]	2004	Turkey Undergraduate and Postgraduate (GPs)	Controlled trial	50 medical students in study group; 54 in control group; and 53 GPs	Teaching sessions based on WHO Good Prescribing Guide	2 written OSCE stations – (i) tonsillitis (ii) mild hypertension	Mean scores of study group were higher than those of GPs, which were in turn found to be higher than those of control group for all cases ($P < 0.05$)	Strength 3–4 Importance 2b
Coombes *et al.* [20]	2007	Australia Undergraduate	Controlled trial	109 medical students in study group; 134 control group	Eight problem-based tutorials covering general prescribing as well as topics such as analgesics, anticoagulants and antibiotics	Written short answers in four prescribing scenarios covering adverse drug reactions, anticoagulants and analgesics	Mean score study group 29.46; control group 26.35 ($P < 0.05$)	Strength 2 Importance 2b
Degnan *et al.* [22]	2006	UK Undergraduate	Randomized controlled trial	9 medical students study; 35 control group	Teaching module on prescribing and administering emergency drugs. Interactive electronic tutorial with 12 multiple-choice questions and three case studies	OSCE station requiring administration of correct dose of lidocaine and adrenaline to patient with anaphylaxis	The teaching module significantly improved the administration of lidocaine (χ^2, $P = 0.005$) and adrenaline (χ^2, $P = 0.0002$)	Strength 3 Importance 2b
De Vries [15]	1993	Netherlands Undergraduate	Randomized controlled trial	203 medical students in 2 study groups; 104 in control groups	Teaching sessions based on WHO Good Prescribing Guide	Written test based on case scenarios – chronic obstructive airways disease and urinary tract infection	There was a retention effect when students were tested with a problem they had been taught on; there was no transfer effect to a new problem. Study groups scored higher than control groups	Strength 3–4 Importance 2b
De Vries *et al.* [16]	1995	Multiple countries – Asia, Africa, Europe & Australia Undergraduate	Randomized controlled trial	91 medical students in study group; 93 in control group	Teaching sessions based on WHO Good Prescribing Guide	Written test based on case scenario assessing drug choice and prescription of pain relief	Significantly better scores immediately post intervention, and at 6 months compared with control	Strength 3–4 Importance 2b

Table 1

Continued

Author	Date	Setting	Study design	Number of participants	Intervention	Outcome measures	Results	Best evidence medical education score*
De Vries *et al.* [17]	2008	Seven countries in Asia & Europe Undergraduate	Randomized controlled trial	194 medical students in the study group; 198 in control group one; 191 in control group two	Teaching sessions based on WHO Good Prescribing Guide (study group = whole manual; control group 1 = manual minus p-drugs), with and without use of personal formulary	Written test with 16 patient cases based on 4 topics – hypertension, osteoarthritis, bronchitis, gastroenteritis	Improvement between study and control group two; minor difference between study and control group one	Strength 3 Importance 2b
Hassan *et al.* [18]	2000	Yemen Undergraduate	Randomized controlled trial	34 medical students in study group; 31 in control group	Four teaching sessions based on WHO Good Prescribing Guide	Written test based on case scenarios covering asthma or diarrhoea	Mean study group 0.17 pre test, 1.40 post test; control group 0.22 pre test, 0.23 post test ($P < 0.05$)	Strength 3 Importance 2b
Kozer *et al.* [24]	2006	Canada Postgraduate paediatric residents	Controlled trial	13 residents in study group; 9 residents in control group	Single 30-min tutorial on prescribing errors, medication in children, and a short written test	Actual prescribing errors in a paediatric emergency department.	No difference in prescribing errors made between study (12.4% errors per item) and control groups (12.7%)	Strength 1 Importance 3
Nelson *et al.* [23]	2000	USA Postgraduate paediatric residents	Controlled trial	20 residents in study group; 10 in control group	Single 30-min teaching session on dose calculation, and short written test	Written test of dose calculation with 8 questions covering 5 scenarios	Pre test mean score 48%. Study group mean score 70% post intervention ($P < 0.001$); control group mean score 49% post intervention	Strength 3 Importance 2b
Scobie *et al.* [21]	2003	UK Undergraduate	Controlled trial	40 medical students in study group; 40 in control	Five pharmacist-led teaching sessions (20 min each) on skills of practical prescribing	9 OSCE stations: anticoagulation, antibiotic administration, drug history, calculation and prescription, use of formulary	Study group mean score 13.7; control group score 10.5 (no *P*-value reported)	Strength 2–3 Importance 2b
Vollebregt *et al.* [19]	2006	Netherlands Undergraduate	Randomized controlled trial	43 medical students in study group; 42 in control group	Teaching sessions covering 4 case scenarios based on WHO Good Prescribing Guide	Skills test covering 21 diseases using 7 case scenarios; and 40 MCQs	Study group mean scores were 26.7% pre test, 46.0% post test and 41.3% after 9 months; control group mean scores were 27.4%, 36.7% post test and 36.3% after 9 months ($P < 0.05$)	Strength 3–4 Importance 2b

*BEME Scoring.

Table 2

Characteristics and findings of 'before-and-after' studies

Author	Date	Setting	Study design	Number of students	Intervention	Outcome measures	Results	Best evidence medical education score*
Garbutt *et al.* [28]	2006	USA Undergraduate students (3rd year)	Before and after	28 students (3 lost to follow-up)	Interactive educational meeting on prescribing errors and a session on behaviour change	Prescribing errors in verbal drug order using 10 clinical scenarios (common medicines, e.g. insulin, morphine)	Mean error-free orders increased from 0.82 to 4.54 per student ($P < 0.0001$), and the mean number of errors per student decreased from 13.96 to 7.36 ($P < 0.0001$)	Strength 2–3 Importance 2b
Karaalp [25]	2003	Turkey Medical students (5th year)	Before and after	79 medical students	Teaching sessions based on WHO Good Prescribing Guide	Marks on OSCE stations (1 'exposed case'; 1 'unexposed case' – disease not specified)	Mean scores for all groups were significantly higher in post test stations than pre test station ($P < 0.05$)	Strength 3 Importance 1, 2b
Vlahovic Palcevski *et al.* [26]	1998	Croatia Medical students (6th year) and GP residents	Before and after	18 medical students; 10 GP residents	Lecture course on prescribing (generic and disease specific topics)	Score on written test based on patient scenarios (respiratory tract infection, acute asthma attack, mild hypertension)	Significant improvement in mean scores on therapeutic aspects following course (students $\chi^2 = 13.5$, $P = 0.0002$; residents $\chi^2 = 8.55$, $P = 0.0035$)	Strength 2 Importance 2b
Wells *et al.* [27]	2002	Canada Undergraduate students (3rd year)	Before and after	21 medical students	Teaching session with pharmacist then practice at medication review with patient	Score on written test (MCQ and SAQ).	Knowledge-based MCQs showed improvements, but no significant change in SAQs (case scenarios)	Strength 2–3 Importance 2b

*BEME Scoring.

Strength

Strength equates with critical appraisal and is a statement of your confidence that the results of the study are credible:

1 No clear conclusions can be drawn; not strong.

2 Results ambiguous; there seems to be a trend.

3 Conclusions can probably be based on the results.

4 Results are clear and very likely to be true.

5 Results are unequivocal.

Importance

Level 1: Participation – covers learners' views on the learning experience, its organization, presentation, content, teaching methods, and aspects of the instructional organization, materials, and quality of instruction.

Level 2a: Modification of attitudes or perceptions – outcomes here relate to changes in the reciprocal attitudes or perceptions between participant groups towards intervention or simulation.

Level 2b: Modification of knowledge and skills – for knowledge, this relates to the acquisition of concepts, procedures, and principles; for skills this relates to the acquisition of thinking and problem solving, psychomotor and social skills.

Level 3: Behavioural change – documents the transfer of learning to the workplace or willingness of learners to apply new knowledge and skills.

Level 4a: Change in organizational practice – wider changes in the organization or delivery of care, attributable to an educational programme.

Level 4b: Benefits to patient or clients – any improvement in the health and well-being of patients and clients as a direct result of an educational programme.

Two studies examined the effect of new clinical pharmacology teaching. Palcevski *et al.* used written patient scenarios to test students before and after a new lecture course in prescribing [26]. This study was limited by selection bias from the voluntary nature of the course, small numbers, and the use of multiple choice questions to test therapeutic decisions. Wells *et al.* investigated the effect of a new teaching session by pharmacists as part of a student geriatrics attachment [27]. Students also undertook a medication review.

Another study evaluated the introduction of a tutorial on prescribing errors, and reported a reduction in student errors. Students were asked to transcribe from verbal instructions, testing only drug order writing [28].

All the before-and-after studies are badly afflicted by the lack of a concurrent control group, absence of blinding and the inability to take into account temporal improvements in the students' ability as they proceed through their training.

Discussion

Although we found 11 controlled trials on educational interventions to improve prescribing skills, the validity and generalizability of these studies are adversely affected by the diversity of interventions and outcome measures. Only one intervention (the WHO Good Prescribing Guide, with six trials) has been tested in a wide variety of international settings and across a range of students at different levels. As all of the other interventions have been tested only in single centres with relatively small groups of students, it is impossible to rule out the specific teacher effect where the positive results may stem from the skills of a particular teacher, and are not reproducible elsewhere.

Although none of the trials provides a definitive answer, their findings give us a useful pointer to the strategies that may be worth pursuing in larger, longer-term trials with hard outcomes. The most thoroughly evaluated intervention and highest quality studies are based on the WHO guide that takes the student through a structured problem-solving six-step process in choosing and prescribing a suitable drug for an individual patient. This has been shown to improve student skills in simulated scenarios across many medical schools, and may be of benefit even to students who have not embarked yet on their clinical placements. In the absence of strong evidence to support the use of other interventions, the WHO model would serve as a good foundation for the design of a targeted prescribing curriculum.

The major strength of this study is that it is a systematic review; however, the conclusions it can draw are limited by the quality of the studies retrieved. Overall, the studies were of poor quality, with small numbers and methodological flaws. In terms of BEME scores, most studies showed only changes in proxy markers, but in the undergraduate setting it is not possible to show changes in patient outcomes. Only one study attempted to measure changes in actual prescription errors – the intervention did not have a demonstrable effect. However, this was a small trial that may have been underpowered and did not use a structured intervention.

Particular themes emerged which contributed to quality. Many of the studies in this review assessed students without discussion of the validity and reliability of the assessment methods. Often a single OSCE station was used, despite the knowledge that a number of stations are needed for reliable assessment [29]. Marking schemes used for elements of drug choice were inconsistent and arbitrary. It was difficult to evaluate the effect sizes reported and whether these were of sufficient magnitude to reflect successful teaching. Although there is logic in the use of each of the WHO guide principles as an assessment criterion, little consideration of relative importance seems to have been made. Another general issue may be potential conflicts of interest for those designing and evaluating interventions. For example, the author of the WHO guide was an author in five of the six trials reported.

Prescribing is a complex task. One of the difficulties for teachers is assessing the separate components of theoretical knowledge applied in tandem with the ability to perform the task safely. A student may have comprehensive understanding of pharmacology, but could write poor quality prescriptions because of lack of care in checking for errors or failure to take an accurate drug history. Whereas some of the included studies were clearly targeted at prescription writing, it was not always clear in other studies whether writing was only a small component of the assessment.

Overall, there is only moderate evidence in the literature to inform medical schools about how best to prepare medical students for the challenges of prescribing that they will face from their first day of work. The WHO Good Prescribing Guide is the only model that has been widely used and shown to have some beneficial effects. The evidence for this needs to be expanded to cover assessment of practical prescribing scenarios in a much wider range of structured clinical stations, with validation of inter-rater reliability. Although the guide is based on sound therapeutic principles, there is clearly a need for further development in teaching and assessment of prescribing.

A number of outstanding issues have been highlighted from the literature. First, a consensus on the skills needed for safe, rational prescribing is needed to inform teaching. Clarity on the desired outcomes in greater detail than is currently available in policy documents such as Tomorrow's Doctor will improve standardization.

Second, further description and evaluation of existing teaching methods will provide evidence about the current situation within the UK.

Third, a valid and reliable mechanism for assessing written prescriptions is required. Outcome measures

should be based on simulated real-life practice involving the completion of actual prescriptions for undergraduates where possible. In the postgraduate arena, real prescriptions could be utilized in assessment. NHS Education for Scotland have a multisource feedback tool under development (Peter Davey, personal communication, 2008), which may be useful.

Competing interests

None to declare.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1
Studies of educational interventions which have been evaluated by students
Appendix S2
Table Study quality using criteria based on Reed *et al.* [11]
Appendix S3
Search strategy

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